Serial No.: 10/605,801
Docket No. P26811

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of | Docket No. P26811

Shaun B. Crawford et al.

Serial No.: 10/605,801 | Group Art Unit: No. 1756

Filed: October 28, 2003 | Examiner: Christopher Young

For: **IMPROVED CD UNIFORMITY OF CHROME ETCH TO PHOTOMASK PROCESS**

DECLARATION UNDER 37 C.F.R. 1.131

Sir:

We, Shaun B. Crawford, Timothy J. Dalton, Thomas B. Faure, Cuc K. Huynh, Michelle L. Steen and Thomas M. Wagner do hereby declare:

1. We are co-inventors of the subject matter disclosed and recited in independent claims 1, 15 and 21 of the above-identified application.

2. We completed the invention of claims 1, 15 and 21 (and those claims dependent thereon) in the United States before March 21, 2003, as evidenced below.

CONCEPTION

3. Before March 21, 2003, we conceived of a photomask and a method for manufacturing a photomask as disclosed and recited in claims 1, 15 and 21 of the application, an embodiment of which is evidenced by IBM Invention Disclosure BUR8-2003-0213US (hereinafter referred to as "the Invention Disclosure") attached hereto as Exhibit A, in addition to other related documents. The Invention Disclosure and other related documents attached hereto

are a photocopy of and are identical to the originals, except that all pertinent dates have been removed therefrom.

4. All dates removed from the Invention Disclosure and other attached documents attached hereto are before March 21, 2003.

5. As evidenced in the attached documents including the Invention Disclosure, the Inventors conceived a method for manufacturing a photomask comprising steps of forming an opaque layer and etching the opaque layer by using a gas mixture having a selectivity of about 1.2:1 between the opaque layer and the resist layer. The Inventors further conceived a method for manufacturing a photomask comprising etching an opaque layer by using a gas mixture of Cl_2, He, O_2 and CO_2 with etch conditions between about a ratio of 40 for O_2 and 10 for CO_2 and 10 for O_2 and 40 for CO_2, wherein the etch conditions provide a zero iteration mask fabrication. The Inventors also conceived of a photomask comprising a substrate and an opaque layer selectively formed on the substrate. The mask is manufactured by steps comprising etching the opaque layer with either a chlorine or fluorine containing species and a gas mixture of O_2 and CO_2 having a selectivity lower than 1:1 between the opaque layer and the resist layer.

7. The benefits and features of the photomask and method of manufacture are shown and described in the Invention Disclosure and accompanying documents.

8. These features and others are exemplified in the figures accompanying the Invention Disclosure.

DUE DILIGENCE

9. Inventors Huynh and Faure communicated with outside patent counsel, Andrew M. Calderon, in preparing a patent application based on the Invention Disclosure.

10. We worked diligently on the preparation of the patent application with outside patent counsel Andrew M. Calderon until a final draft patent application was completed to our satisfaction. Communications took place between the Inventors and Mr. Calderon on at least September 17, 18, 22 and 23, 2003 A final draft of the application was forwarded to IBM in-house patent counsel, Richard Kotulak, who received the final draft from attorney Calderon in a letter dated October 7, 2003.

11. The final draft of the patent application was filed in the U.S. Patent and Trademark Office on October 23, 2003 by IBM counsel.

12. We declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further, that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Shaun B. Crawford	Date
Timothy J. Dalton	3/25/05 Date
Thomas B. Faure	Date
Cuc K. Huynh	Date
Michelle L. Steen	3/25/05 Date
Thomas M. Wagner	Date

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PATENT & TRADEMARK OFFICE

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Thomas B. Faure	3/23/05 Date
Cuc K. Huynh	3/23/05 Date
Michelle L. Steen	Date
Thomas M. Wagner	3/23/05 Date

Main Idea for Disclosure BUR8- _213

Prepared for and/or by an IBM Attorney - IBM Confidential

Archived On

Title of disclosure (in English)
Improve CD Uniformity of Chrome Etch with CO2/O2 addition to the Photomask Process

Main Idea of disclosure
1. Background: What is the problem solved by your invention? Describe known solutions to this problem (if any). What are the drawbacks of such known solutions, or why is an additional solution required? Cite any relevant technical documents or references.

This disclosure was SEARCH RATED at the Mask House Scrub Session attended by Rick Kotulak (attorney) and Tom Faure - Emily Fisch (SBC).

In addition, this disclosure will be FILE / MERGED as a preferred embodiment into disclosure (attached below for reference andembedded into the disclosure write-up below in blue font where appropriate).

BUR820020205.lwp

PROBLEM

This invention relates to dry etching and more particularly to methods for dry etching of metals or metal compounds or other materials that can be anisotropically etched using gaseous mixtures that contain chlorine with carbon dioxide, or alternately chlorine and carbon monoxide, as the etchant species.

High CD Uniformity caused by the range between the KERF and Internal Array. Using CO2/O2 in the plasma chrome dry etch, the CD Uniformity and Range of the PCI measurements across the mask improves (gas ratios and etch data attached below).

BACKGROUND

High CD Uniformity has always been, in the past, the limiting factor of the Mask house to meet the customer' s uniformity specification. This issue of not meeting the 3 sigma specification has kept the Mask house from meeting the Wafer line Lithography water fall chart for CD Uniformity. Most recent enhancement to the Mask etch process is to add 8mm Clear Bars to the outside of the Kerf frame. The addition of CO2/O2 to the plasma Cr dry etch process yields further improvements to the CD Uniformity and PCI ranges values instead of just using Clear Bars and is disclosed in this document.

2. Summary of Invention: Briefly describe the core idea of your invention (saving the details for questions #3 below). Describe the advantage(s) of using your invention instead of the known solutions described above.

INVENTION SUMMARY

Dry etching of layers of material for subsequent use as either photolithographic, X-ray, or e-beam masks, is important, for example in conjunction with fabricating semiconductor integrated circuits or other devices.

Such masks are used for pattern transfer from the mask to the device. The mask is formed by patterning an opaque layer on a transmitting substrate according to a desired pattern. The opaque layers masks are commonly chromium, chromium-containing compounds, molybdenum alloy, and tungsten. For example, a conventional mask comprises a structure in which a chromium layer, which is an opaque layer, is formed on a light-transmitting substrate, such as a quartz substrate. Furthermore, a chromium oxide layer for preventing reflection by the chromium layer may be formed on the chromium layer. An organic resist is then formed on the chromium or chromium oxide layer, and the resist is patterned, as by optical or electron beam scanning followed by wet developing. A dry etching method is typically used to remove the exposed chromium oxide/ chromium layer by means of a plasma process using a gaseous mixture of chlorine and oxygen as the etchant species. Finally, the resist layer is removed.

A problem with the foregoing process is a low selectivity of the plasma etching of chrome layer relative to the etching of the resist. The low selectivity between the resist and the chrome layer requires the thickness of the resist layer to be undesirably high, thereby limiting the resolution of the patterned chrome layer. Furthermore, the selectivity between the chrome and the resist layer is highly sensitive to the amount of chrome exposed to the etchant species as a sharp decline in the selectivity is observed with increasing chrome load. In the process of the present invention, the patterned is transferred from the resist into the underlying chromium layer using a plasma gas mixture containing chlorine and carbon dioxide, or alternately, chlorine and carbon monoxide to enhance the etching selectivity that can be obtained during etching of the chrome layer and reduce the macroloading effect characteristic to etching chrome in a chlorine-based etch chemistry.

CO2 gas was added to the mask etch chemistry, and the current POR O2 and He flow ratio was adjusted, to optimize the the Plasma Chrome Dry etch process (CD Uniformity, selectivity, etc.). The above adjustements resulted in dry etch improvements that were confirmed through Mask House Engineering experiments. Supporting post-etch mask measurement data is detailed in the files below and will be incorporated into disclosure BUR8-2002-0205; docket BUR9-2003-0030:

GPUL PC data.12: EMU Exp matix.12:

One theory behind why the above improvements are observed is that the CO2/O2 ratio makes the micro loading effects less sensitive to High and Low Resist load density area.

3. Description: Describe how your invention works, and how it could be implemented, using text, diagrams and flow charts as appropriate.
see above

IDT Team

Response Due to IP&L

Tom Faure/Burlington/IBM
Emily Fisch/Burlington/IBM

1. Describe your invention, stating the problem solved (if appropriate), and indicating the advantages of using the invention.
This invention relates to dry etching and more particularly to methods for dry etching of metals or metal compounds or other materials that can be anisotropically etched using gaseous mixtures that contain chlorine with carbon dioxide, or alternately chlorine and carbon monoxide, as the etchant species.
2. How does the invention solve the problem or achieve an advantage,(a description of "the invention", including figures inline as appropriate)?
Dry etching of layers of material for subsequent use as either photolithographic, X-ray, or e-beam masks, is important, for example in conjunction with fabricating semiconductor integrated circuits or other devices. Such masks are used for pattern transfer from the mask to the device. The mask is formed by patterning an opague layer on a transmitting substrate according to a desired pattern. The opaque layers masks are commonly chromium, chromium-containing compounds, molybdenum alloy, and tungsten. For example, a conventional mask comprises a structure in which a chromium layer, which is an opaque layer, is formed on a light-transmitting substrate, such as a quartz substrate. Furthermore, a chromium oxide layer for preventing reflection by the chromium layer may be formed on the chromium layer. An organic resist is then formed on the chromium or chromium oxide layer, and the resist is patterned, as by optical or electron beam scanning followed by wet developing. A dry etching method is typically used to remove the exposed chromium oxide/ chromium layer by means of a plasma process using a gaseous mixture of chlorine and oxygen as the etchant species. Finally, the resist layer is removed.
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3. If the same advantage or problem has been identified by others (inside/outside IBM), how have those others solved it and does your solution differ and why is it better?
Chemically-amplified resist or e-beam resist is mainly used as the photoresist layer. These resist materials have a low etching selectivity with respect to the chrome layer, however, the aforementioned problems associated with dry etching chrome using a gaseous mixture of chlorine and oxygen are still observed. In addition, gaseous mixtures of nitrogen, chlorine, and oxygen or, alternately helium, chlorine, and oxygen, have been used to reduce the macroloading effect associated with dry etching chrome, however, the chrome to resist selectivity obtained with these chemistries is less than that for chlorine and oxygen.
4. If the invention is implemented in a product or prototype, include technical details, purpose, disclosure details to others and the date of that implementation.
N/A

*** Question 1**

On what date was the invention workable? **Please format the date as MM/DD/YYYY**
(Workable means i.e. when you know that your design will solve the problem)

*** Question 2**

Is there any planned or actual publication or disclosure of your invention to anyone outside IBM? No

CO2/O2 Cr Etch Evaluation
9S2 GPUL PC layer

High O2 (40 sccm) yields higher etch rates for Cr and Resist; but worst selectivity

CO2 only addition to Cl2 gas chemistry does not improve selectivity of Cr:Resist

Selectivity improves w/ higher ratio of CO2 to O2 Gas Flow (1.2:1 for Cr:Resist)

At high CO2 vs O2 gas ratio: resist rate drops dramatically and results in highest electivity obtained for such a large Cr area (greater than 8000mm2)

(See graphs on page 2 & 3)

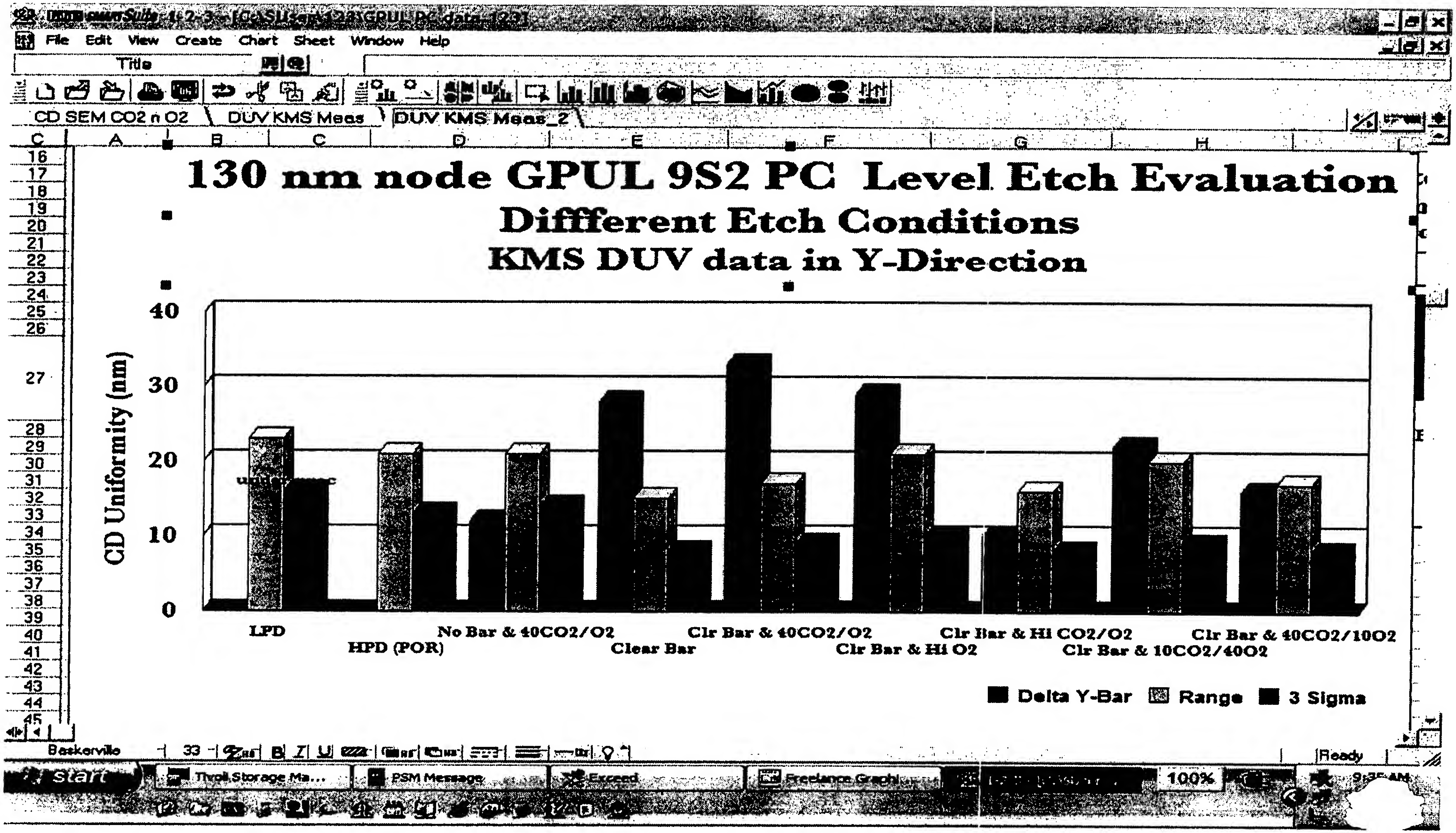
Best 3 Sigma and Range observed with "EMU" process (under 10 nm & 20 nm espectively, see graph on page 4 & 5)

Stable, clean etch process: uniformity improvement has been observed for nVidia, Xilin nd U3 PC layers. All at or under 10nm for 3 sigma.

All PC build layers with EMU process have been stocked on "zero" iteration

Endpoint time is equivalent to POR (RAT2X) for such high Cr etch area (see graph on age 6)

Plot of CD data in Y-direction (DUV KMS Measurements)



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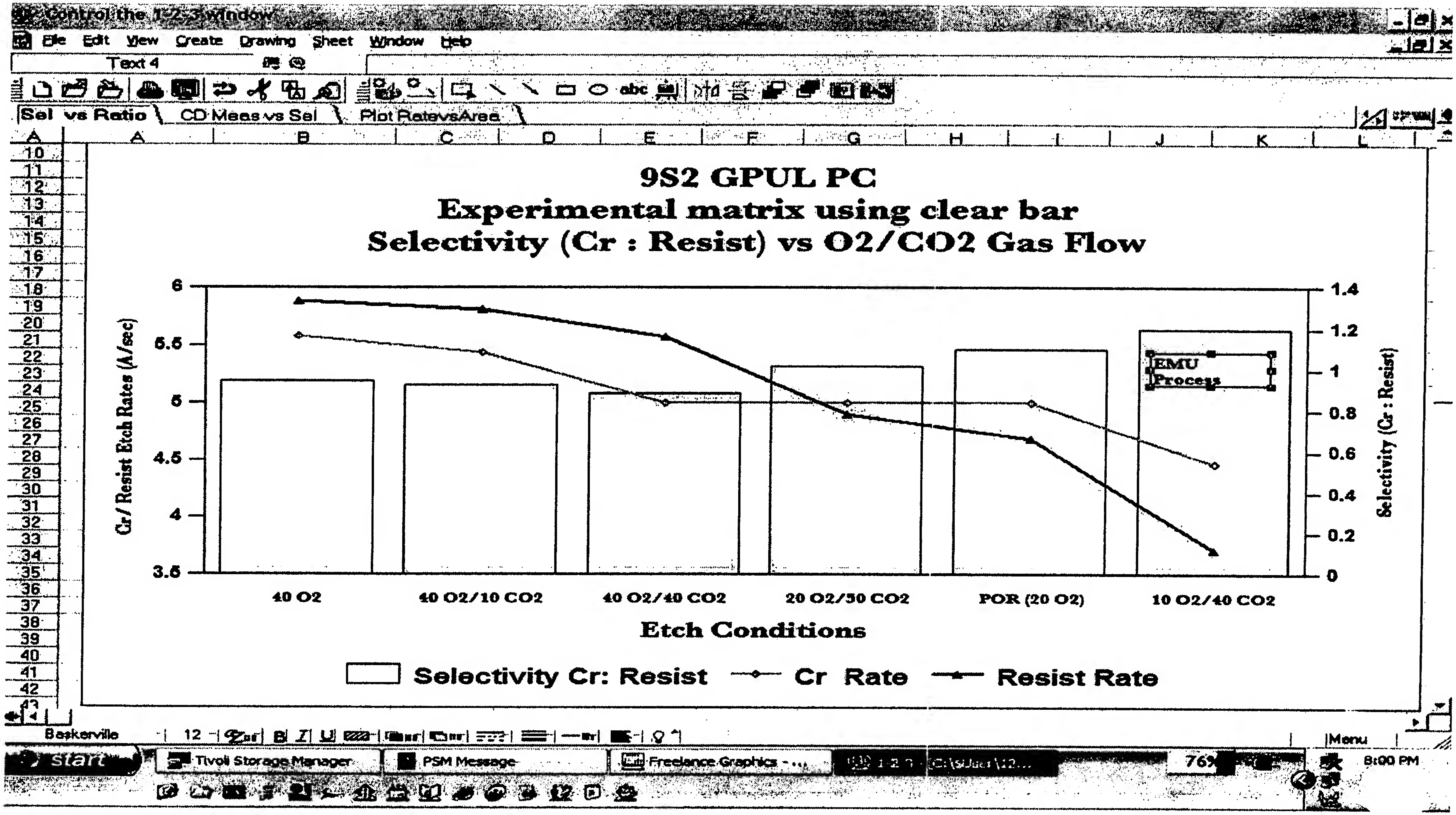
Plot of Selectivity vs Cr and Resist Etch Rates



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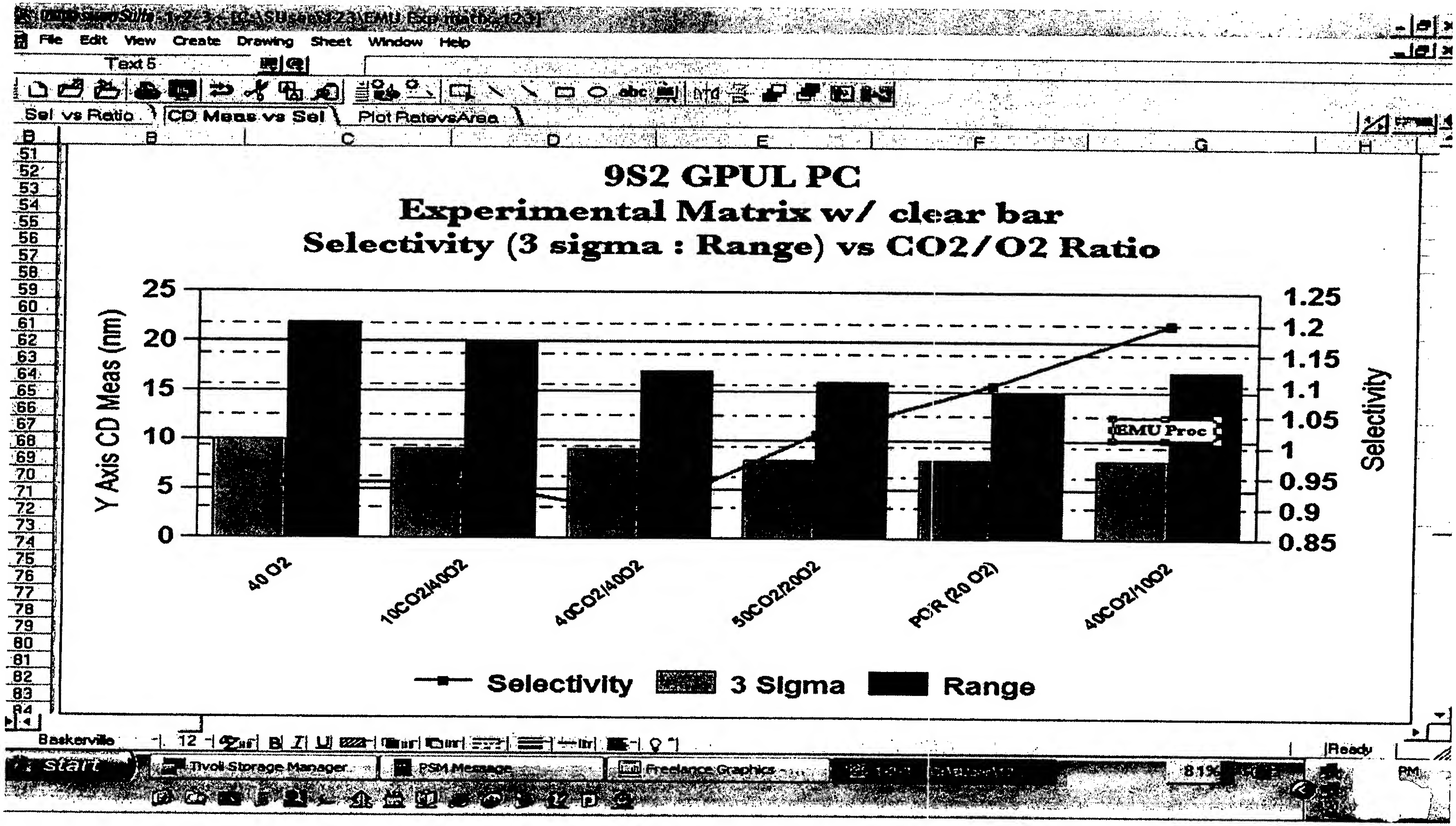
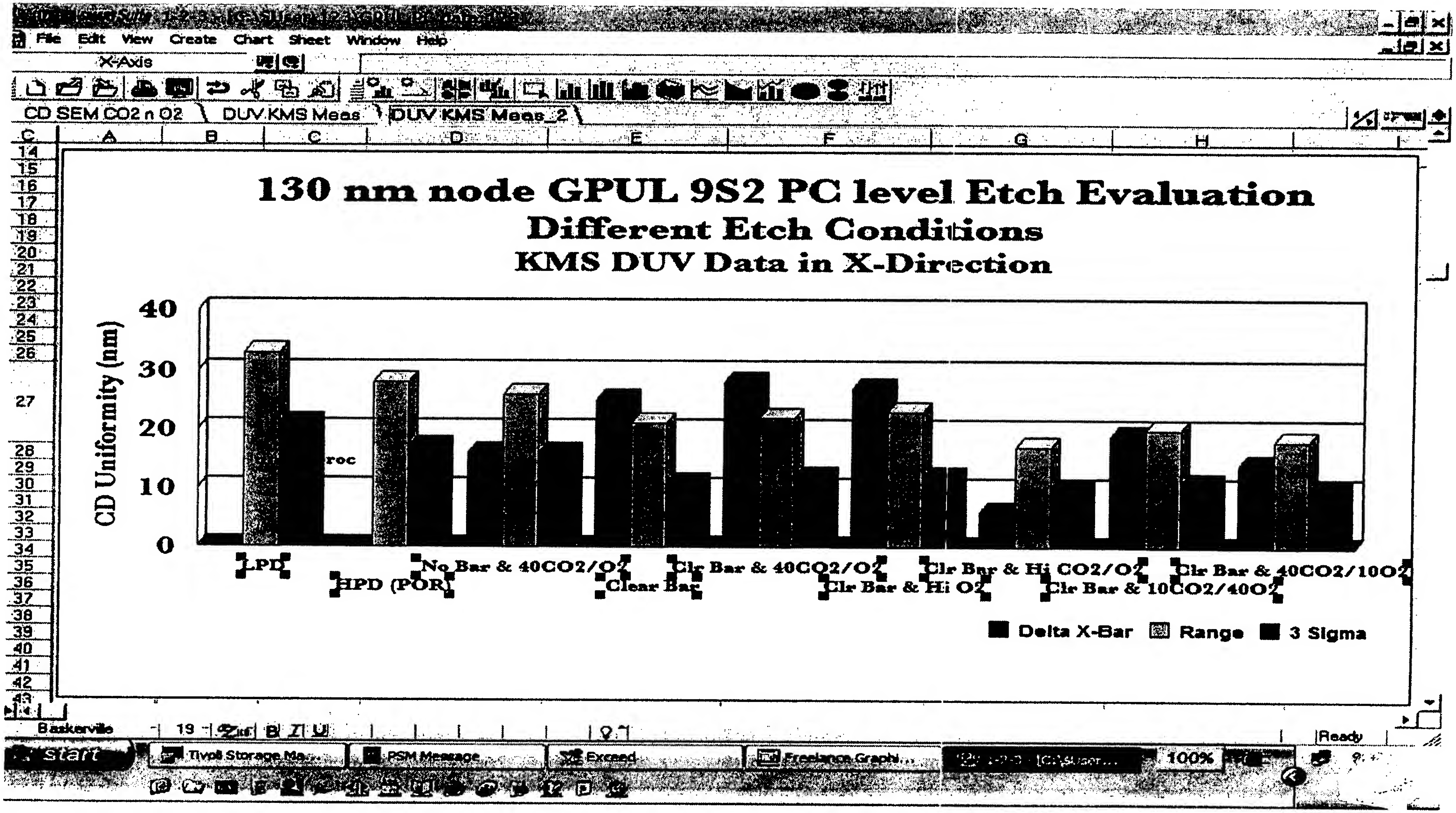
Plot of Selectivity vs CD uniformity



Plot of CD data in X-direction (DUV KMS Measurements)



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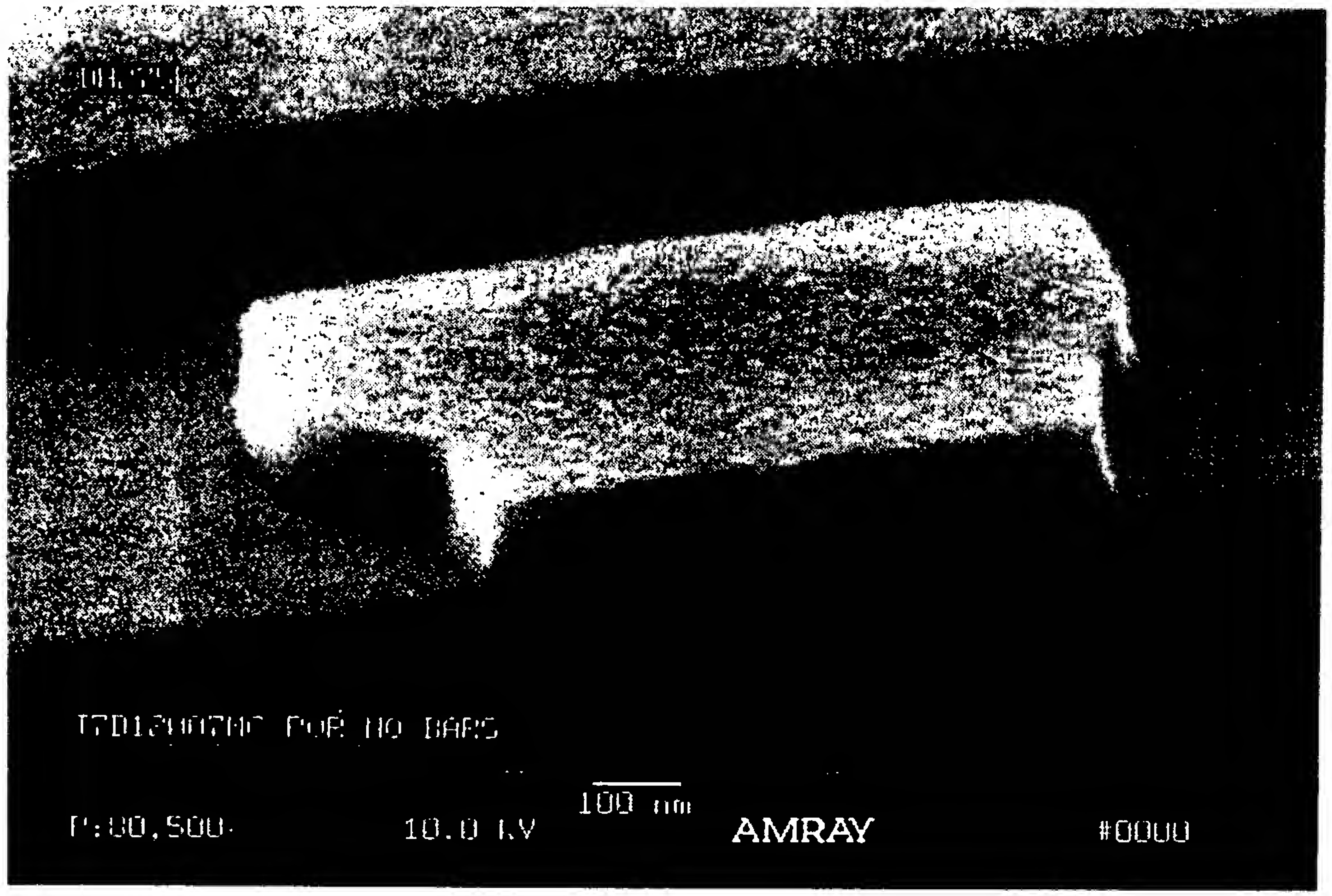
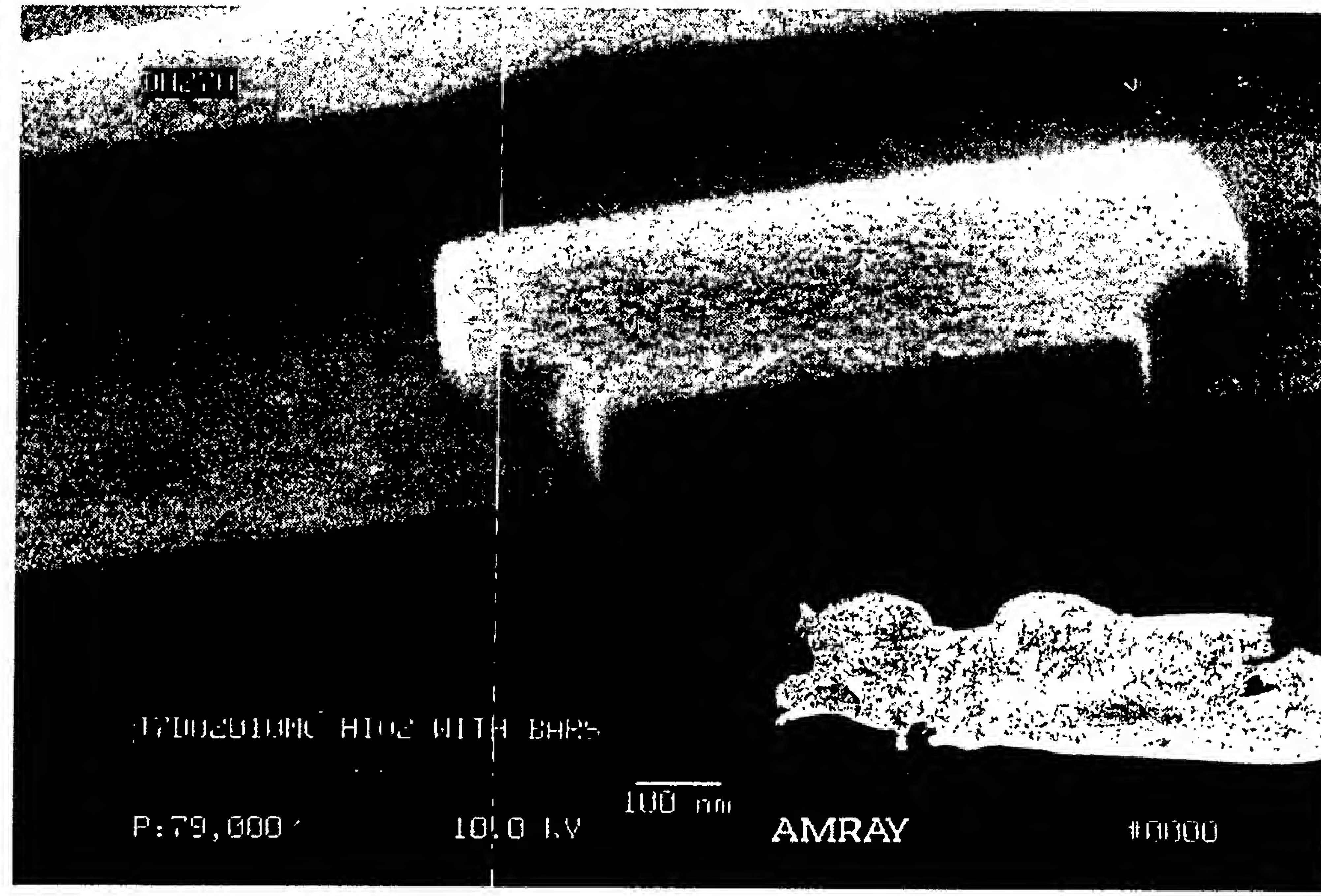
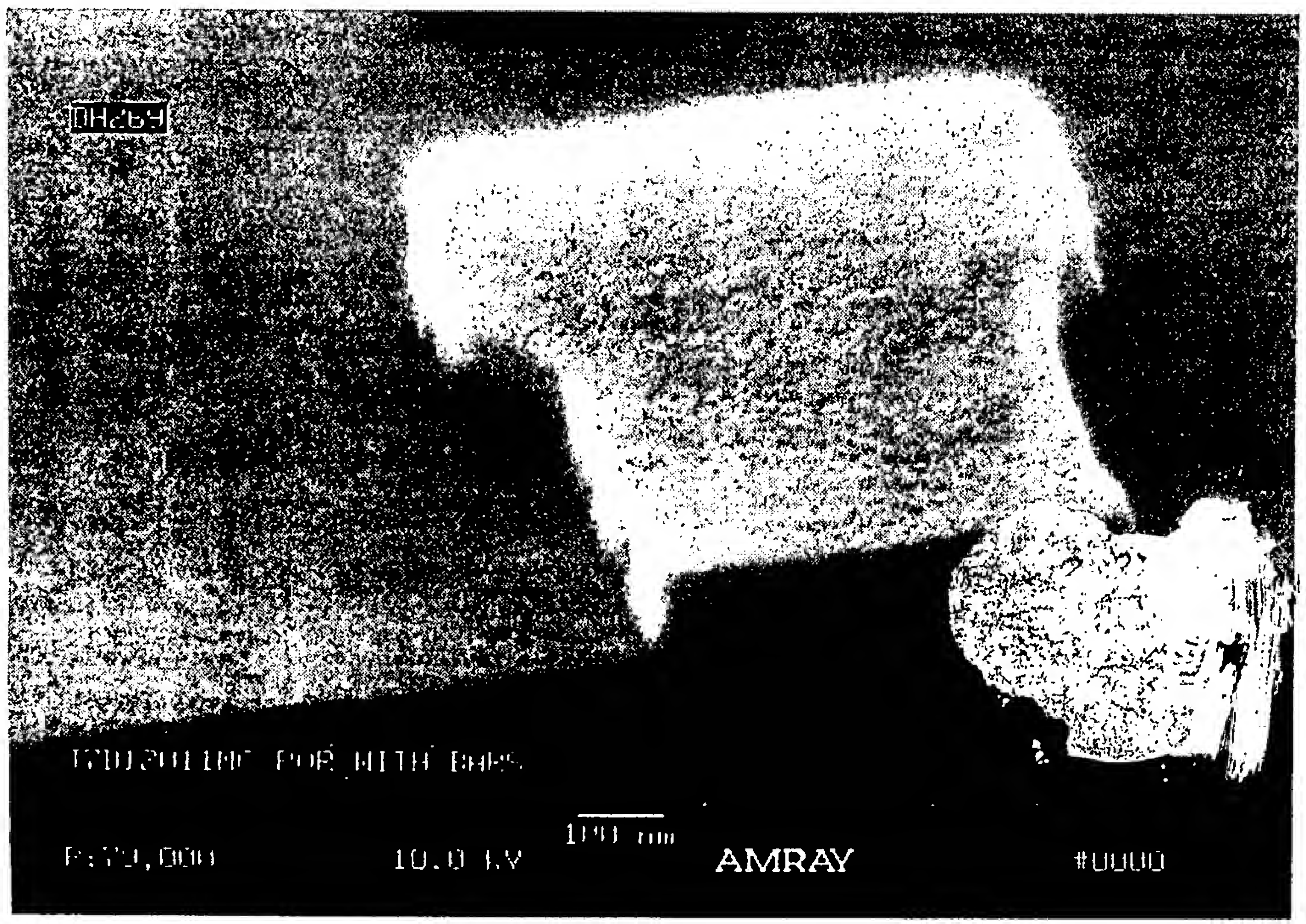


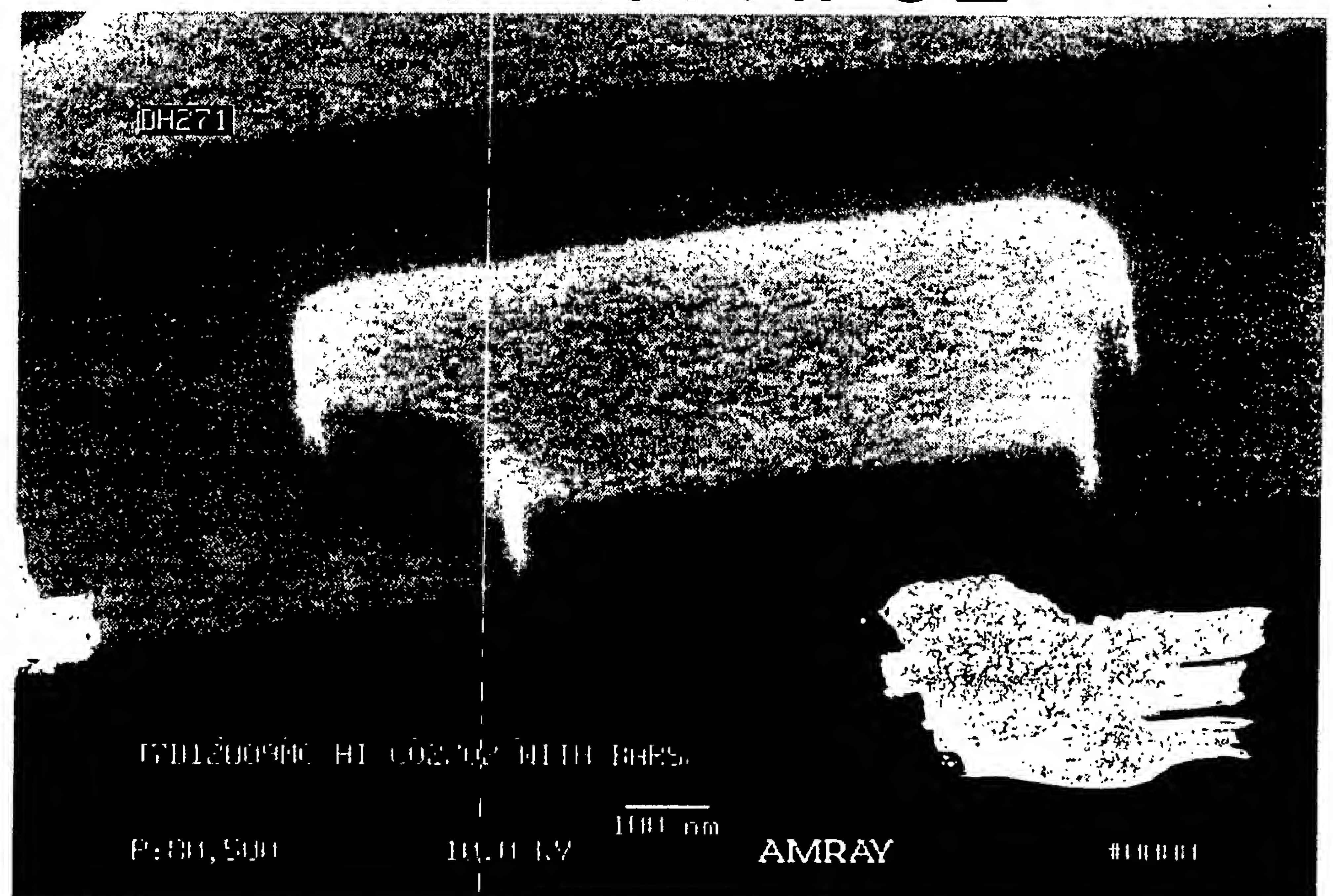
POR No Bars



Bars with Hi O2



POR with Bars



Bars with Co2/O2